the magnetising current. Amongst other points referred to in this connexion is the time-lag in magnetisation, which is well shown by the curve-tracer, and the effects are compared of the same cycle of magnetic force gone through at various speeds. It is shown that in solid bars 1·9 cm. in diameter, especially in soft iron, remarkable evidences of time-lag are seen, even when the period of magnetic reversal is as long as 3 secs. The work spent per cycle is a maximum at a particular frequency, which in such bars is very low.

The fourth and last section of the paper relates to the molecular theory of magnetisation, and describes experiments made with groups of small pivoted magnets. It is shown that the behaviour of such groups, when exposed to the action of a variable magnetic field, presents striking points of resemblance to the behaviour of iron or steel under corresponding variations of magnetising force. Results are given which tend to confirm the theory.

The particulars of the observations are set out in about forty sheets of curves which accompany the paper.

III. "Polarisation of Platinum Electrodes in Sulphuric Acid." By JAMES B. HENDERSON, B.Sc. Communicated by LORD KELVIN, P.R.S. Received June 10, 1893.

This investigation was begun about the beginning of February, 1893, at the instigation of Lord Kelvin, and was conducted in the Physical Laboratory of Glasgow University. The object of the investigation was to obtain the difference of potential between two platinum electrodes immersed in a solution of sulphuric acid immediately after the stoppage of a current which had been electrolysing the solution, and to find how this difference varied with a variation in the intensity of the current or in the strength of the solution.

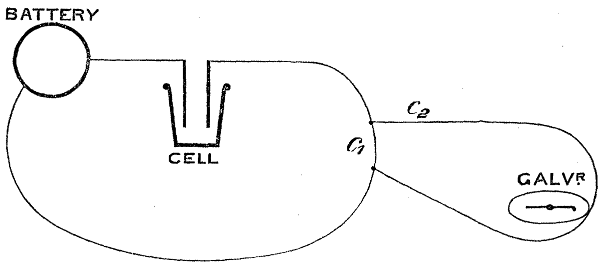
Former experiments by Buff ('Poggendorff,' vol. 130, p. 341, 1867) and Fromme ('Wiedemann,' vol. 33, p. 80, 1888) have given for the maximum polarisation with platinum wires of very small surface in the electrolysis of dilute sulphuric acid 3·5 and 4·6 volts.

Dr. Franz Richarz, in a paper "On the Polarisation of Small Electrodes in Dilute Sulphuric Acid," read before the British Association at Bath (1888), says of the above :—

"In these experiments the polarisation is calculated from measurements of the intensity of the galvanic current during the electrolysis, tacitly assuming that the resistance of the decomposition cell is independent of the intensity of the galvanic current. The correctness of the supposition has not been proved. I tried experiments by similar methods, and obtained yet greater values of the polarisation; it was calculated with a current density of 12 ampères per square

centimetre as 4·4 daniells (4·7 volts), and increased more and more with increasing intensity of the galvanic current. It is very improbable that this can be right. By supposing, however, that the resistance of the decomposition cell is not independent of the intensity, but decreases in a fixed manner with increasing intensity, the calculation of the same experiments gives small and constant values of polarisation."

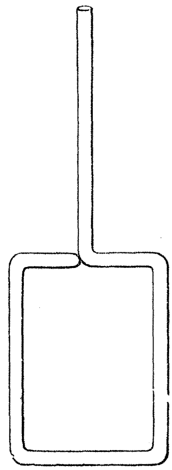
FIG. 1.



The method Dr. Richarz used to find the polarisation in his investigation was independent of the resistance of the electrolytic cell. The battery electrolytic cell and a switch, c_1, were joined in closed circuit. A branch circuit containing a very high resistance, a galvanometer, and another switch, c_2, joined the two sides of the switch c_1 (c_1 and c_2 were the two contacts of a Helmholtz's pendulum interrupter). When c_1 was made there was a very small current through the galvanometer. To determine the polarisation c_1 was broken, and immediately after c_2 also. In the short time between the interruption of c_1 and c_2 a current strong for the sensibility of the galvanometer went through it. The polarisation was calculated from the deflection given to the galvanometer needle by the impact of the current, which was proportional to the electromotive force of the battery *minus* the polarisation. In this way Dr. Richarz found values for the polarisation never greater than 2·6 volts with small wire electrodes, and also got the same maximum with large platinum plates.

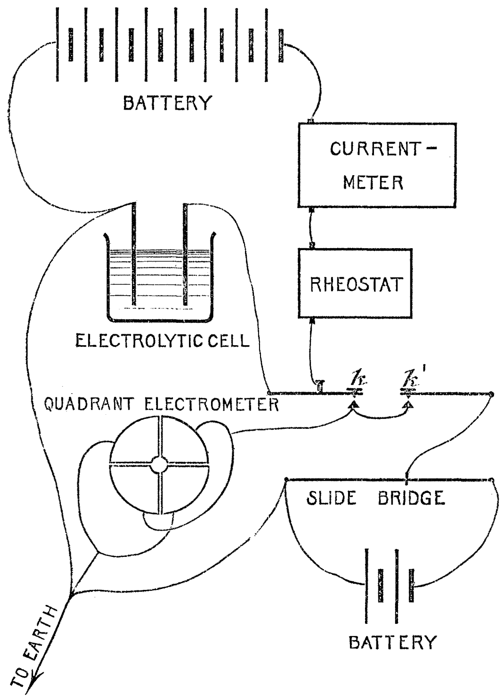
The cell used in the present investigation was a cylindrical glass vessel 10 cm. diameter and 12 cm. deep. The electrodes were rectangular plates of platinum foil 7 cm. long by 5·5 cm. broad, and were stiffened by being mounted on rectangular frames made by bending glass tubing (fig. 2). The tubing of these frames also served to support the plates in vertical planes by being passed through holes in a bar of wood placed across the mouth of the vessel. The plates were immersed in the solution to a depth of 5 cm., having their planes parallel and about 1 cm. apart. There were thus 55 sq. cm. of surface of each plate wetted. To find the polari-

FIG. 2.



sation one of Lord Kelvin's quadrant electrometers was used, and by an arrangement, described later, the breaking of the electrolysing current circuit and the switching of the electrodes on to the terminals of the electrometer were done simultaneously. Before switching as above, however, the needle of the electrometer was deflected by making a difference of potential between the pairs of quadrants, and this deflection was so adjusted by trial and error that, when the electrodes were switched on, the needle was no farther deflected. For deflecting the needle of the electrometer a high resistance slide bridge was used. A difference of potential was maintained between its two ends, and the difference of potential between one end and the slider was used to deflect the needle, so that by moving the slider one way or the other the deflection could be increased or diminished at will. The electrolysing current was kept constant throughout each experiment, being measured by one of Lord Kelvin's electric balances and adjusted by a rheostat. One terminal of the electrometer, one electrode, and one end of the slide bridge were connected together and then put to earth. The current for the electrolysis was got from eight large secondary cells, and the difference of potential between the ends of the slide bridge was maintained by two small secondary cells. The arrangement of keys can be best understood from the diagram. By pressing the key k', connexion was made between the slider and the unearthed quadrants, and when the key k was free, the circuit was complete for the electrolysing current, but when k was pressed down the circuit was broken, and the unearthed electrode was connected to the unearthed quadrants.

Fig. 3.



The order of an experiment was the following.

After carefully standardising the electrometer, the electrolysis was started, and the unearthed electrode connected by a wire (not shown in the diagram) to the unearthed quadrants. The deflection of the needle thus produced, which showed the difference of potential between the electrodes, continued to increase steadily until, after the lapse of an interval of time depending on the strength of the current, it became constant. When this stage was reached, the wire mentioned above was removed and the key k' pressed and kept down, thus making connexion between the slider and the quadrants. The slider was then moved along until the deflection was nearly equal to that which would be given by the polarisation, and the key k momentarily pressed, thereby breaking the current circuit and connecting the electrode to the quadrants. An impulsive deflection immediately followed, unless the potential of the quadrants was equal to that of polarisation. If this deflection was negative (which indicated that the potential of polarisation was less than that of the quadrants) the slider was moved so as to reduce the potential of the quadrants below that of polarisation, thereby making the impulsive

deflection positive, and then the experiment was continued as below. When the positive deflection was obtained its amount was noted, and the slider was moved so as to increase the steady deflection nearly up to the point on the scale reached by the impulsive one, and another trial then made. In this way, by watching the point reached by each impulsive deflection, and then increasing the steady one almost up to that point, the latter was increased until the former vanished, that is, until the potential of the quadrants was that of polarisation. The magnitude of this deflection was then noted, and the polarisation calculated from it. In these trials the key k was kept down only for about two seconds, just sufficient time to allow the extent of the deflection to be seen, and at least two minutes were allowed to elapse between one trial and the next.

After the maximum deflection had been reached, a considerable interval of time was allowed to elapse, and then the key k' raised and k simultaneously lowered and kept down, and the rate of fall of the deflection noted. The above motion of the keys threw the slider off and put the electrode on to the quadrants, at the same time stopping the current. The deflection was therefore due to polarisation alone, and its rate of fall was therefore the rate of fall of the polarisation.

The results of one series of experiments are given in the accompanying table.

All the results point to the polarisation being constant with large electrodes, being independent of the strength of the solution and the intensity of the current. The variations in the figures do not occur

Percentage strength of solution.	Strength of current in ampères.	Time the current had been passing. h. m.	Polarisation in volts.
30	0·2	3 25	2·066
,,	0·5	0 45	2·060
,,	1·0	0 35	2·060
,,	1·0	0 45	2·124
20	0·1	3 22	2·126
,,	0·5	1 25	2·139
,,	1·0	0 25	2·090
,,	1·0	0 35	2·124
10	0·1	17 40	2·139
,,	0·5	1 19	2·066
,,	1·0	0 44	2·066
5	0·1	18 30	2·116
,,	0·5	1 36	2·078
,,	1·0	1 0	2·083
,,	1·0	3 15	2·054

Mean polarisation = 2·09 volts.

in any order, and are all such as might be expected in experimental results of this nature. Some of the greatest variations were obtained in exactly similar experiments performed at different times.

The mean of all the values of the polarisation in this table is 2·09 volts.

The rate of fall of the polarisation depends on the time the current has been electrolysing the solution, and also on its intensity, but in every case the fall is very rapid at first, being in some cases as much in the first minute as it is in the next five minutes, and the fall in the first minute is never less than one-fourth of the polarisation.

IV. "On the Annual and Semi-annual Seismic Periods." By CHARLES DAVISON, M.A., Mathematical Master at King Edward's High School, Birmingham. Communicated by Professor J. H. POYNTING, F.R.S. Received June 13, 1893.

(Abstract.)

Method of Investigation.—The method adopted is similar to that employed by Dr. C. G. Knott in his paper on "Earthquake Frequency."

If $f(\theta)$ be a periodic function of θ, then

$$f(\theta) = a_0 + a_1 \cos(\theta + \alpha_1) + a_2 \cos(2\theta + \alpha_2) + \ldots + a_n \cos(n\theta + \alpha_n) + \ldots,$$

from which it follows that

$$\frac{1}{\pi}\int_{\theta-\pi/2}^{\theta+\pi/2} f(\theta)\,d\theta = a_0 + \frac{2a_1}{\pi}\cos(\theta+\alpha_1) - \frac{2a_3}{3\pi}\cos(3\theta+\alpha_3) + \ldots + \frac{2a_n \sin\frac{n\pi}{2}}{n\pi}\cos(n\theta+\alpha_n) + \ldots.$$

This latter expression gives the mean value of $f(\theta)$ through an interval $\pi/2$ on either side of θ. From it, all terms involving even multiples of θ are eliminated, and the coefficients of all terms after the second are diminished to a greater extent than that of the second.

A definition of the unit earthquake having been adopted, the earthquakes of different districts are classified in half-monthly groups, the first half of February containing fourteen days, and of all the other months fifteen days; and the numbers so obtained are reduced to intervals of equal length (fifteen days). The numbers for the two halves of each month are added together. The mean of the numbers for the six months from November to April gives the six-monthly